9

425674

Final Report on NASA Grant NAG-1-2064

Studies of Radiation and Microphysics in Cirrus and Marine Stratocumulus Clouds

The final year of funding under this grant provided limited support for three activities. These were (1) theoretical studies of cloud microphysics, (2) a joint experimental project with NASA Langley Research Center (LaRC) to remote sense cirrus ice mass, and (3) writing a science plan for a proposed tropical cirrus experiment.

Theoretical studies of cloud microphysics

Two tasks were completed during this period. In the first, we examined the polarization of millimeter-wavelength radar beams scattered by ice crystals. Because of their non-spherical shape and size, ice crystals depolarize the incident polarized radar beam. In principle, this depolarization can be used to identify ice from liquid water, as well as provide some information on size. However, the amount of de-polarization is small, producing only a weak signal at the receiver. Our task was to determine the magnitude of such a signal and decide if our radar would be capable of measuring it under typical cirrus conditions. The theoretical study was carried out by Henrietta Lemke, a visiting graduate student from Germany. She had prior experience using a discrete dipole code to compute scattering depolarization. Dr. Kultegin Aydin of the Penn State Electrical Engineering Department, who is also expert in this area, consulted with us on this project at no cost to the project. Our conclusion was that the depolarization signal is too weak to be usefully measured by our system. Therefore we proceeded no further in this study. A paper was subsequently written by Ms. Lemke and is attached to this report.

The second task involved the study of the effect of stratus microphysics on surface cloud forcing. Manajit Sengupta, a graduate student, and the project PI jointly carried out this task. The study used data culled from over a year of continuous radar and radiometer observations at the Atmospheric Radiation Measurement (ARM) site in Oklahoma. The study compared solar radiation calculations made using constant microphysics with calculations made using a retrieved mean particle size. The results showed that on average the constant microphysics produced the correct forcing when compared with the observed forcing. We conclude, therefore, that there is little impetus on radiation grounds alone to include explicit microphysics in climate models. The question of pollutant particle emission impacts on microphysics remains to be resolved. A conference abstract on this project is attached to this report. A manuscript is in preparation and will be submitted this year.

Experimental project with LaRC

At least two research groups have recently proposed that sub-millimeter radiometry from space can be used to measure the ice water path in cirrus clouds. Briefly put, the idea is to measure the reduction of upwelling thermal infrared radiation at sub-millimeter wavelengths caused by cirrus clouds. The reduction is due to backscatter of this emitted radiation by ice crystals. Measuring the reduction at a minimum of two wavelengths allows one to infer both the mean crystal size and the total ice mass. A research group at NASA LaRC is working on such a radiometer and flying it for test purposes on a small

NASA jet. We participated in a several week exercise with this group, led by Ira Nolt, that attempted to overfly our radar at Penn State with the airplane so that we could measure the bulk cirrus properties with the radar and infer the ice mass. Our participation included operating the radar and helping forecast appropriate conditions. Dave Babb, a post-doctoral research associate, was primarily responsible for the Penn State effort. Results of the combined experiment are not yet available.

CRYSTAL

For a number of years, the PI has been advocating a field program to study the properties and radiative effects of tropical cirrus. During the period of this grant, the PI in conjunction with several other scientists devoted considerable time to working on a science plan for such an experiment. This science plan was completed and will serve as the background document for a NASA request for proposals in the near future.